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Interactive comment

Interactive comment on "Examining regional groundwater-surface water dynamics using an integrated hydrologic model of the San Joaquin River basin" *by* J. M. Gilbert and R. M. Maxwell

Anonymous Referee #2

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General comments

In this manuscript the authors aim to examine regional groundwater-surface water interactions and dynamics using an integrated model for the San Joaquin River basin. The authors start with a brief description of the model construction, followed by the validation of the model for groundwater levels, runoff and streamflow, snowpack, evapotranspiration and water storage. Following the validation, which the authors consider as satisfactory, the model is used for studying groundwater and land surface budgets, as well as groundwater-stream interactions. This is a high quality manuscript where the authors successfully employ a large number of data to validate a highly complex model, which then allows the authors to address highly relevant scientific questions

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Discussion paper

through the analysis of simulation results. Some of the choices during model design require a more detailed justification, such as the choice of a predevelopment situation or the selection of the year of interest (2009), please see specific comments below.

Specific comments

The paper is quite large and detailed, and yet lacks some detail on study area characterization, model calibration, sensitivity analysis or justification of certain choices.

In section 2 when the authors describe the conceptual model, they could give a first broad characterization of average annual precipitation (rainfall and snow), evapotranspiration. Also please indicate the total area of the basin in this section

Pg. 3. When the authors mention the main outflows, they do not consider groundwater. Do the authors think there might be any lateral groundwater outflows from the basin, through deep circulation and/or along faults.

Pg. 4. What is the estimated maximum thickness of the Corcoran Clays and to what extent may it hamper the upward flow of groundwater from deeper layers in the groundwater discharge area? As a consequence, what could be the impact of the oversimplification of the bottom layer? Was the presence of the Corcoran Clays taken into account when assigning the hydraulic conductivity values to the layer? Did the authors consider assigning a separate model layer to the clays? In Appendix B it is mentioned that they consider the current configuration as “a reasonable first approximation”, does this mean that research on increasing vertical discretization of the aquifer is ongoing?

Pg. 4 The authors mention the Coast Range mountain blocks are built up of marine sedimentary rocks, whereas the Sierra mountain blocks are predominantly granite. The authors then conceptualize them as one and the same system with non-zero permeability through a depth of 500 m. Later on the authors perform a very interesting sensitivity analysis on mountain block permeability. My question is whether the authors initially thought of considering the Coast Range and Sierra mountain blocks as individual systems, since secondary porosity and permeability in carbonate rocks can be much higher due to dissolution/karstification phenomena, quite different from intrusive rocks.

I would like to read a bit more about the authors' justification for a using a (quasi-)predevelopment state to conceptualize the system in the model. I understand modelling a heavily altered state is much more complex. Notwithstanding, as the authors rightly mention, the calibration and validation of such a model is difficult. But more importantly, what can be said about the impact of human activities ("groundwater pumping, stream impoundments and reservoirs, or surface water diversions on the system") on the system, i.e. to what degree have they altered the dynamics that occurred in the predevelopment phase and are now simulated by the model? That is an important open question that remains to be answered (as the authors acknowledge in the summary and conclusions).

During parameterization of the model, did the authors perform any uncertainty/sensitivity analysis, besides the one mentioned for mountain block hydraulic conductivity? In particular, the authors opted for a single specific storage value for the entire model domain, and I would like them to explain how they calibrated this parameter and how sensitive the temporal groundwater storage changes are to this parameter. And regarding the K values, how do they vary spatially over the model domain?

For what reason did the authors use 2009 as your period of interest for simulation, and how does that year compare to an average year in terms of precipitation and temperature?

Comparison to observations: the authors mention that "considering aggregate behavior at a regional scale (1000-10000 km2) reduces some of the impact of local hydrologic perturbations sufficient to permit reasonable comparison of simulated and observed variables". On what do the authors base this assumption? And what about the regional hydrologic perturbations? It is known that the heavy groundwater pumping has caused large regional perturbations, including water table lowering and land subsidence. In the water table map (section 4.1) the authors mention that land subsidence could explain part of the (high) discrepancies found between observed and modelled water table heights. Sparse point measurements could be another factor of influence, particularly close to the rivers. It would be good to see the location of the observation points in the map of Figure 2. The huge modelled hydraulic gradients on the western border of the area seem rather odd, in some cases decreasing from 90 m to 0 m in a few km. How can this be explained?

For runoff and streamflow (section 4.2) the authors use monthly “full natural flow” values provided by CA-DWR. How can these data be used to evaluate the correct representation of peak flows? In general, the authors acknowledge that for several reasons comparisons are difficult to make. They mention that the model tends to under-predict monthly flow volumes. What water balance parameter is then overestimated by the model? Strangely, in Fig. 3 I notice a systematic overestimation by the model of streamflow in the first months of the hydrological year. Please comment.

On evapotranspiration (section 4.3) how reliable are the results of the MOD16 global ET product? Have they been compared to other estimates of ET? I am also asking because I find the total recharge of the aquifer to be very low (Table 1, 2-3% of precipitation). For a sedimentary aquifer receiving diffuse recharge from direct rainfall, as well as significant mountain front recharge from rivers flowing out of the mountains onto the coarse-grained alluvial cones, I would expect recharge fractions of over 10% of watershed precipitation.

Regarding terrestrial water storage it is interesting that the authors use GRACE to verify the model results. One question I do have is how valid these comparisons are if you consider that large amounts of water are currently withdrawn for irrigation, thus constituting a significant loss factor that is not taken into account in the model but will show up in the GRACE signal. This is acknowledged by the authors, but they mention that the redistribution of water across the domain will have compensated these losses.

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Please elaborate on this a bit.

On the groundwater budget (section 5.1) why is there a small aquifer-wide drop in the water table if the year is close to average in terms of climate and there are no groundwater abstractions?

Sections 5.1-5.3 are overall very well written and interesting to read. The figures used are clear, illustrative and well thought through.

Technical corrections

Pg. 2 ln 25: components Pg. 3 ln 10: temporal dynamics of

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